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A Study on Complementary Code Keying Demodulation in 802.11b Wireless LAN

Kenji Yokoyama†, Miyoshi Saito††, Hirohisa Gambe††, Kiyomichi Araki†

†Graduate School of Science and Engineering, Tokyo Institute of Technology

††Fujitsu Laboratories Ltd.

1. Preface

There is the 802.11b model as an example of the high-speed wireless LAN used in the indoor environment. This uses CCK (Complementary Code Keying) as a modulation scheme by which to realize the transmission rate of 5.5 Mbps and 11 Mbps in the 2.4 GHz band. In this paper, we evaluate the characteristics of a modulation scheme of CCK in the specifications at a receiving side, using the maximum likelihood estimation method, under the additive noise environment and fading environment.

2. Structure of 802.11b

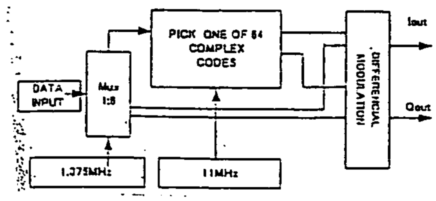

FIG. 1: CCK modulator at 11 Mbps

The CCK, which is a modulation scheme realizing max. 11 Mbps in IEEE 802.11b, is configured as shown in FIG. 1. The input data are serial-parallel converted per 8 bits, and the 2 bits uses the DQPSK modulation method and the 6-bit information is CCK modulated so as to achieve high speed [1].

3. CCK (Complementary Code Keying)

If, in the CCK modulation, $d_i,\ i \in \{0,1,2,3,4,5,6,7\}$ is 8-bit information, these will be modulated into four phase values $\varphi_i,\ i \in \{1,2,3,4\}$ by performing DQPSK modulation on d_0 and d_1 (determination of φ_1) and performing QPSK modulation (determination of φ_2, φ_3 and φ_4) on d_2 to d_7.

$$\mathbf{c} = \{e^{j(\varphi_1+\varphi_2+\varphi_3+\varphi_4)}\},\ e^{j(\varphi_1+\varphi_3+\varphi_4)},\ e^{j(\varphi_1+\varphi_2+\varphi_4)},\ -e^{j(\varphi_1+\varphi_4)},$$

$$e^{j(\varphi_1+\varphi_2+\varphi_3)},\ e^{j(\varphi_1+\varphi_3)},\ -e^{j(\varphi_1+\varphi_2)},\ e^{j(\varphi_1)}\}$$

$$= e^{j\varphi_1}\{e^{j(\varphi_2+\varphi_3+\varphi_4)}\},\ e^{j(\varphi_3+\varphi_4)},\ e^{j(\varphi_2+\varphi_4)},\ -e^{j(\varphi_4)},\ e^{j(\varphi_2+\varphi_3)},$$

$$e^{j(\varphi_3)},\ -e^{j(\varphi_2)},\ 1\}$$

$$= e^{j\varphi_1}\,\tilde{c} \qquad \text{--- (1)}$$

By substituting φ_j into Equation (1), a 8-bit code is created so as to be transmitted [2]. ($\tilde{\mathbf{c}}$ is a code constituted by 6 bits)

4. CCK Decoding

(1) AWGN (Additive White Gaussian Noise) model

$$\mathbf{r}=\mathbf{c}^{(k)}+\mathbf{n} \qquad \text{--- (2)}$$

If a received signal in the additive noise environment is given by Equation (2), a code $\hat{\mathbf{c}}^{(k')}$ giving the most likelihood will be obtained using Equation (3) in order to estimate the optimum transmission code. ($\mathbf{n}$: Gaussian Noise, k=1, 2, … 256)

$$\hat{\mathbf{c}}^{(k')}=\arg \underset{\mathbf{c}^{(k)}}{\mathrm{Max}} \mathrm{Re}(\mathbf{r}^{\dagger}\mathbf{c}^{(k)}) \qquad \text{--- (3)}$$

(2) Fading model

$$\mathbf{r}=A\mathbf{c}^{(k)}+\mathbf{n} \quad (A \text{ : fading coefficient}) \qquad \text{--- (4)}$$

When a received signal in a fading environment is given by Equation (4), the most likelihood code is obtained from the condition (5). It is assumed that the fading coefficient A is known in the receiving side.

$$\hat{\mathbf{c}}^{(k')}=\arg \underset{\mathbf{c}^{(k)}}{\mathrm{Max}} \mathrm{Re}(A\mathbf{c}^{(k)}) \qquad \text{--- (5)}$$

5. Characteristic evaluation by simulation

A comparison is made, in the evaluation of bit error rate under the AWGN environment and the fading environment,

between a case where, in the 8-bit information, 6-bit code is estimated from $Max|\mathbf{r}^{\dagger}\tilde{\mathbf{c}}|$ and the remaining 2 bits are obtained from DQPSK and a case where the entire 8-bit code $\mathbf{c}$ is estimated from the code correlation. The result of simulation under the AWGN environment is shown in FIG. 2 and the result under the fading environment is shown in FIG. 3.

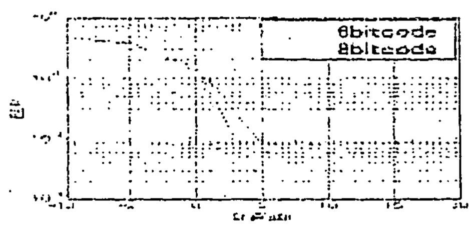

FIG. 2: Error rate characteristic in AWGN

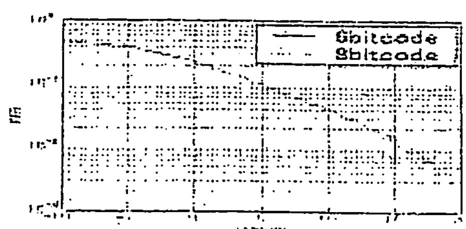

FIG. 3: Error rate characteristic in the fading environment

6. Conclusion

Since not much difference was observed in BER between the estimation result by the 6-bit code correlation and the DQPSK demodulation and that by the 8-bit correlation, the processing by the 6-bit code is found to be effective also. Furthermore, an investigation on the error rate

characteristics in a delayed wave environment is also scheduled.

REFERENCES

[1] Bob O'Hara and Al Petrick, "IEEE802.11 Handbook; A Designer's Comparison" p154, IEEE Press 1999

[2] IEEE Std 802.11b-1999 (Supplement to ANSI/IEEE Std 802.11, 1999 Edition)